- Exposure interval (in seconds) for 60-percent overlap
- Ground gained
- Ground coverage per inch of negative and exposure intervals

When you intend to use the BM-38A computer, refer to the *Photographic Computer Instruction Book,* RC-025063, for detailed instructions.

SCALE

Usually, the area to be mapped is indicated on a chart and maximum boundaries are provided. The scale fraction of this chart, or its linear scale, provides important information. The amount of area to be covered can be determined from one of these scales.

The scale of a map is indicated as a common fraction or as a ratio. For example, the scale may be 1/10,000 or 1:10,000 on the map. In either case, the scale is read "one to ten thousand." This scale indicates that one unit of measure on the map is equal to 10,000 of the same units on the ground.

One problem in aerial mapping is locating the scale of the mosaic map. When the required scale is provided, then the altitude and focal length must be determined to get the required scale. The scale of a photographic mosaic map is calculated as follows:

S = Scale of the map

F = Focal length of the lens

A = Altitude above the ground

With F (in inches), A (in feet) must be multiplied by 12 to convert to the same unit of measurement (inches).

$$S = \frac{F}{12A}$$

Example: What is the scale of a map taken from an altitude of 5,000 feet, using a 6-inch lens.

$$S = \frac{6}{12 \times 5{,}000} = \frac{6}{60{,}000} = \frac{1}{10{,}000}$$

Therefore, the scale is 1/10,000. That means 1 inch on the photograph equals 10,000 inches on the ground.

FORWARD OVERLAP

To ensure complete coverage of the area, you should take each photograph in each flight line or strip so it overlaps both the preceding photograph and the following photograph. The amount of overlap on each photograph is approximately 60 percent. Creating this overlap ensures that the strip contains no blank areas (fig. 4-17).

The overlap also serves another important function. In the construction of a mosaic map, only the central area of each print is used. Only the central area is used because the middle areas of all vertical photographs are the area of truest reproduction of terrain. (See fig. 4-18.)

In figure 4-18, the aircraft is flying over a mountain while making a series of vertical photographs. For all practical purposes, when the aircraft is directly over the mountain, a perfect reproduction of the mountain is obtained. Pictures taken before and after the one directly over the mountain show the near side of the mountain clearly, but very little, if any, of the far side. This is caused by the different camera positions in respect to the subject.

Scale is affected by this difference of camera positions. It is practically impossible to match the edges of prints when these distortions of the terrain are present. Therefore, the outer area (toward the edges of the print) is discarded and the inner 40 percent of each print is used. Another important reason for using only the center area of the prints is that stereoscopic measurement associated with either contour mapping or photographic interpretation requires the highest degree of accuracy.

Since a 60-percent overlap is created, only 40 percent of the ground-gained forward (GGF) is usable in each negative. For example, a 5- × 5-inch negative has a usable image area of 2 inches. ($5.0 \times 0.40 = 2.$) To find the actual amount of usable GGF in each negative, multiply the ground coverage by 0.40. For example, using the IFGA formula, you have determined that the ground coverage for each negative is 9,000 feet. The usable GGF in each negative is 3,600 feet ($9{,}000 \times 0.40 = 3{,}600$).

SIDE LAP

The area that you are photographing for a mosaic map may be wide and cannot be photographed in one strip. The aircraft must fly a number of side-by-side strips to get complete coverage so none of the area is

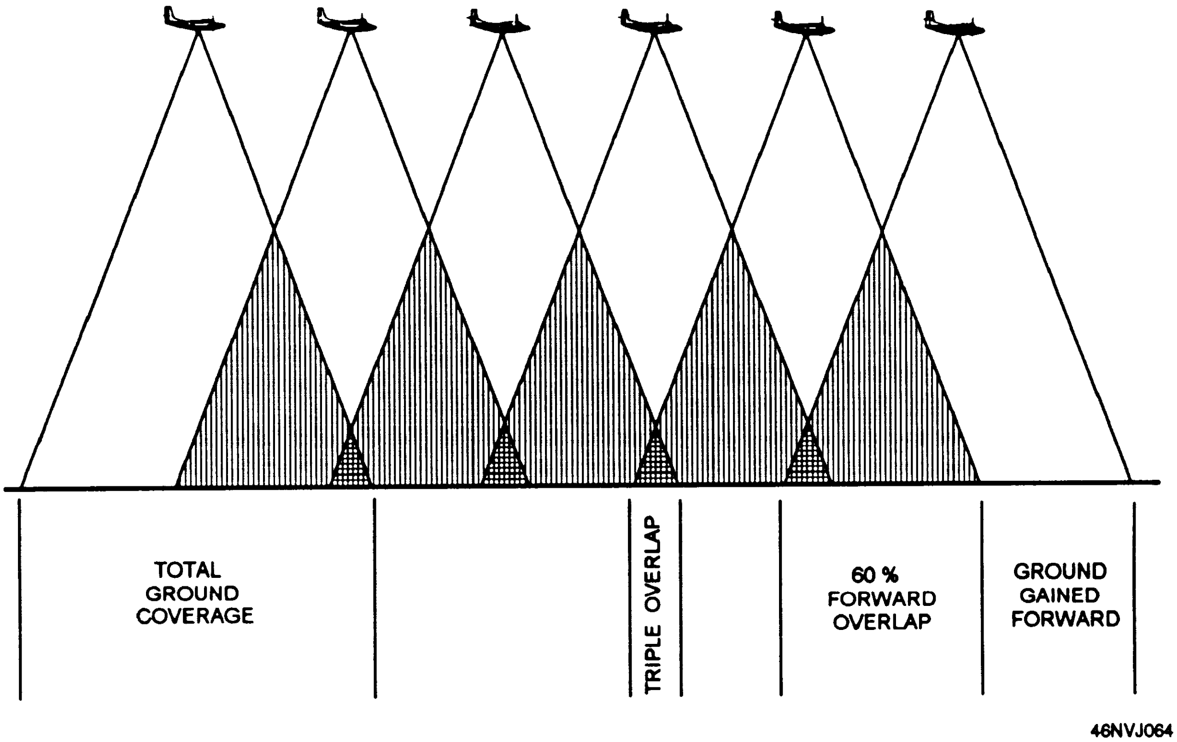


Figure 417.—Forward overlap.

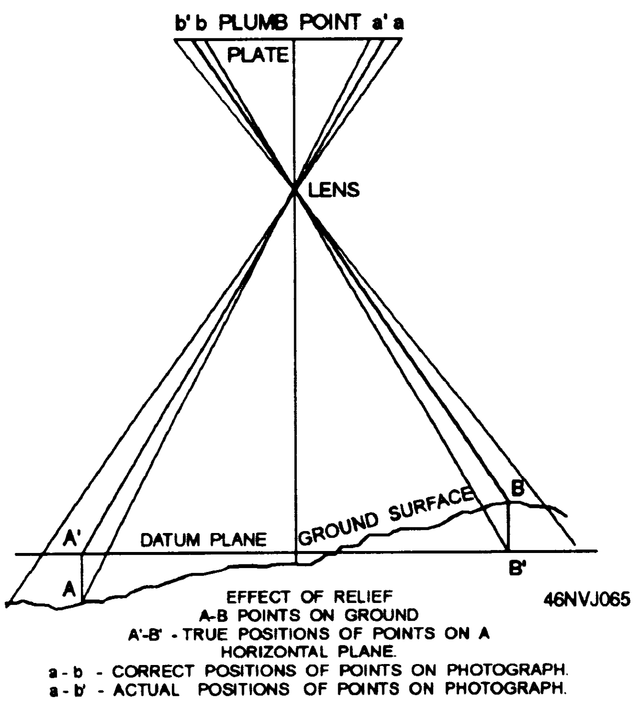


Figure 4-18.—Effect on scale when photographing over rough terrain.

Since each flight strip is overlapped 40 percent, only 60 percent of sideways usable area remains on each negative. To find the amount of usable ground-gained sideways, multiply the ground coverage by 0.60. For example, when the ground coverage is 9,000 feet, the usable ground-gained sideways (GGS) is 5,400 feet ($9{,}000 \times 0.60 = 5{,}400$).

The shorter dimension of the negative is always used for the GGF. This is to limit the number of flight lines to as few as possible. This helps to eliminate the missed. Since only the central portion of each photograph is used in a mosaic map, each successive strip must overlap the preceding strip. This overlapping of strips is called SIDE LAP. Side lap for mosaic maps is usually 40 percent (fig. 4-19).

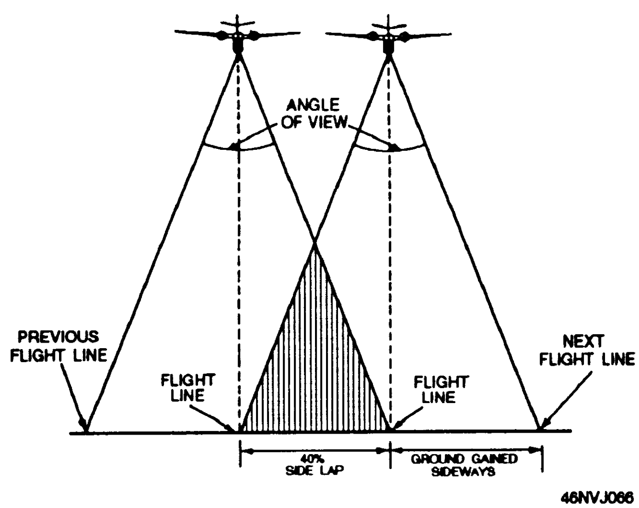


Figure 419.—Side lap.

possible error in lining up each successive flight line. The longer dimension of the film is always used for the GGS.

Figure 4-20 shows the usable portion of a 9- × 9-inch negative after the GGF and GGS have been factored in.

NUMBER OF EXPOSURES

When you are flying for mosaic mapping purposes, the flight strips are usually made along the long dimension of the area being photographed. This practice reduces the number of turns the aircraft must make to photograph the strips. For example, if the area to be photographed is 5 nautical miles east and west by 10 nautical miles north and south, the strips should be flown north and south.

To determine the number of exposures per strip, you should divide the ground-gained forward into the length of the map. When the unit of measurement is in nautical miles, you must convert it into feet (1 nmi = 6,080 ft). Therefore, if the area to be photographed is 10 nautical miles, the area when converted to feet is 60,800 (10 × 6,080).

You add four additional frames to each strip. Two additional photographs should be taken just before reaching the beginning point and two just after the ending point. These four photographs allow for possible errors in reading the beginning point and the ending point of the run on the ground (from the data shown on the flight chart).

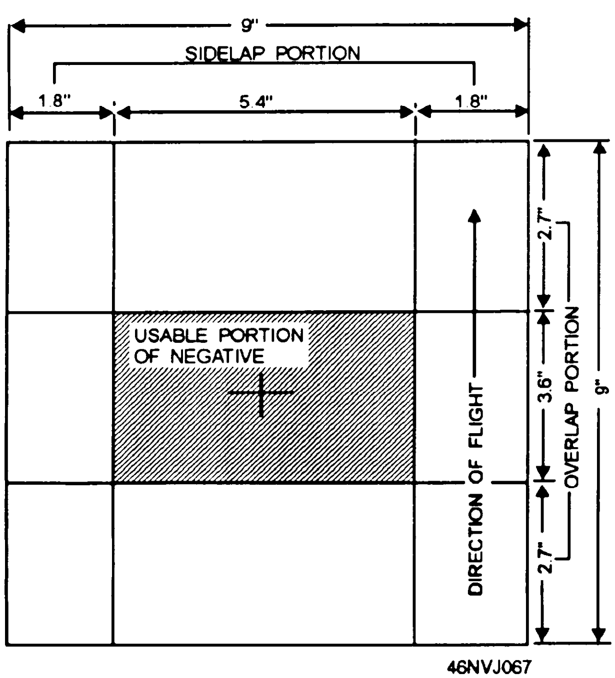


Figure 4-20.—Usable portion of a 9- × 9-inch negative.

You must first calculate the total number of flight strips required to cover the area. Next, divide the ground-gained sideways (GGS) by the total width of the area to determine the total number of strips. Always add one additional strip to your calculations. To determine the total number of photographs (frames) required for the entire mosaic mission, multiply the number of photographs required for each strip by the number of strips.

If the camera can hold enough film for the entire mission, you should have no problem. However, if the camera does not hold enough film for the entire mission, you either have to change film between strips or be prepared to make several flights.

FLIGHT LINES

Before the mapping flight, you should plot the flight lines for each run and draw them on the flight chart with a color that is easily recognizable. Draw the first flight line along the border of the area to be photographed. The remainder of the flight lines should be evenly spaced and parallel to one another.

Figure 4-21 shows a nomograph that can be used to determine the number of flight lines required to cover the target. This nomograph is for low-altitude coverage only.

The nomograph (fig. 4-21) is used as follows:

1. Place a straightedge on the width of the area to be searched and another along the altitude to be flown.

2. Note the intersection on line R_1.

3. Place a straightedge on the point on R_1 and another along the field of view of the camera lens.

4. Note the intersection on line R_2.

5. Move to R_3, keeping the same relative positions on segments R_1 and R_2.

6. Place a straightedge on the point on R_3 and another along the side lap required.

7. Read the number of flight paths (to the largest whole number).

To determine the distance between the plotted lines on the chart, you must change the ground-gained sideways into inches and multiply it by the scale (fraction) used on the chart. For example, if the GGS is 5,400 feet, or 64,800 inches, and the scale of the chart

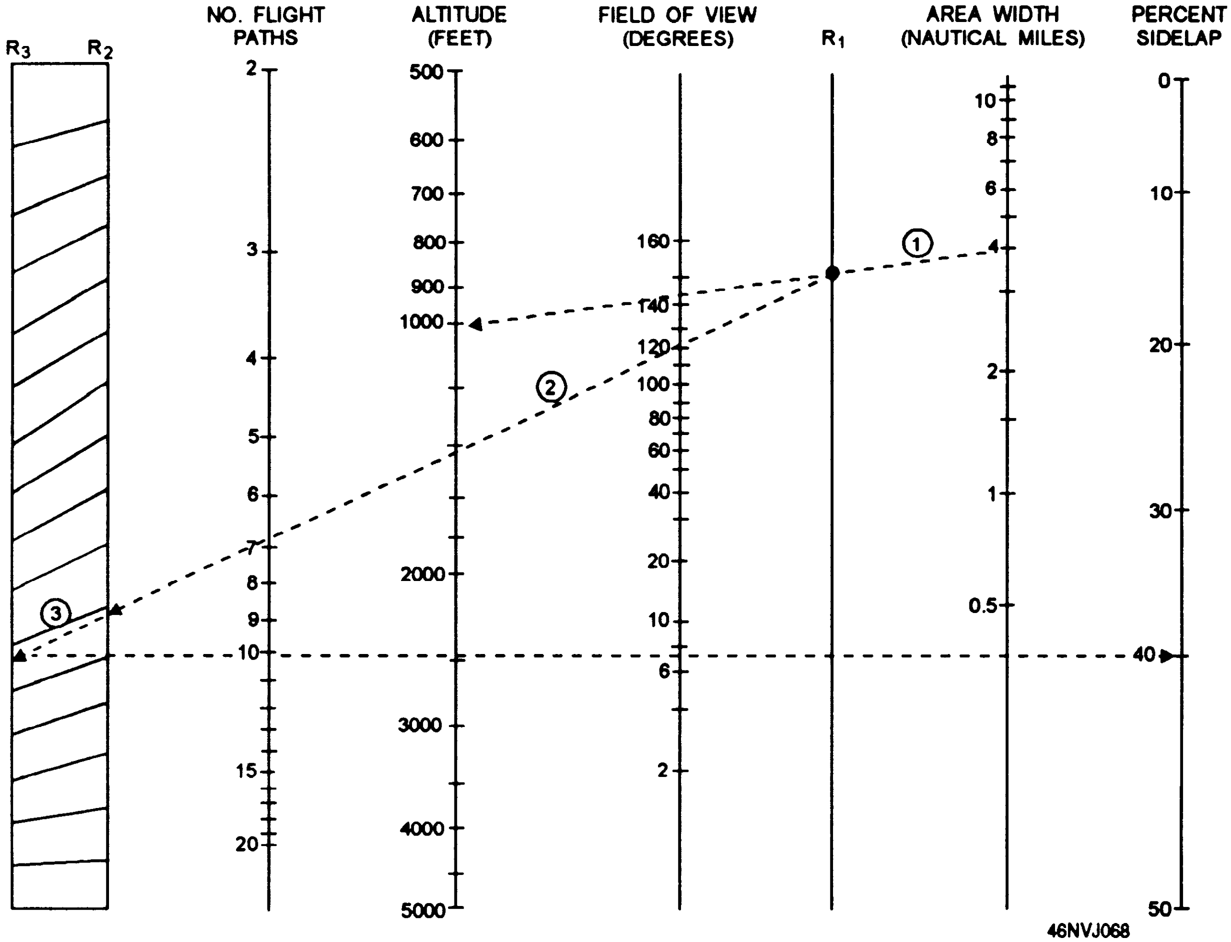


Figure 4-21.—Number of flight lines nomograph.

is 1/10,000, the distance between flight lines drawn on the chart is 64,800 × 1/20,000, or 3.24 inches. Since it is difficult to measure the flight-line distances accurately, a multi-finger divider should be used (fig. 4-22).

To use the multi-finger divider, first multiply the distance between flight lines by the number of fingers on the divider. This will give you the total flight-line plot width. Using a ruler, place the first divider finger on zero and the last divider finger on the mark corresponding to the total flight-line plot width. The individual fingers of the divider automatically space themselves to the correct distance for each flight line. The multi-finger divider may then be used to lay out the flight-line plots.

INTERVAL BETWEEN EXPOSURES

You must convert the aircraft ground speed to feet per second to determine the exposure interval or frequency between frames. The conversion factor for

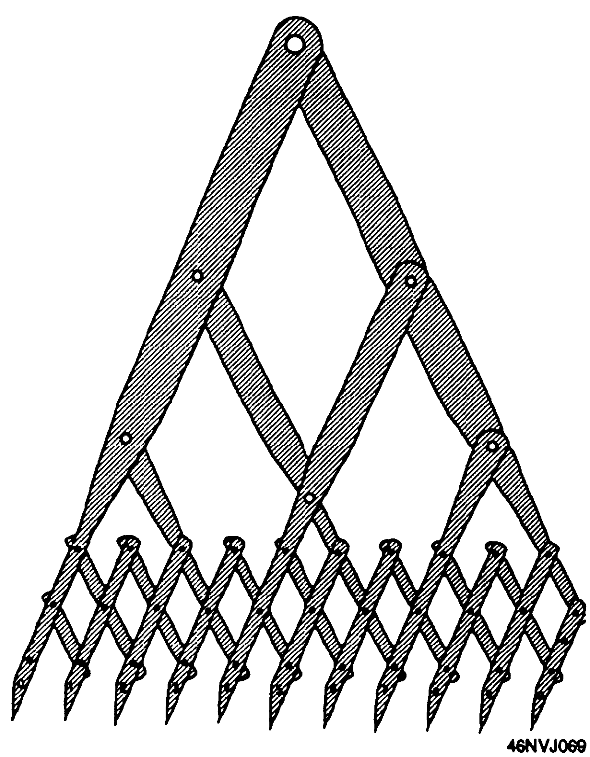


Figure 4-22.—Multi-finger divider.

converting airspeed (in knots) to feet is 1.7 (kts $\times$ 1.7 = ft/sec). For example, when the airspeed is 125 knots, the ground speed, in feet, is 212.5 feet per second (125 $\times$ 1.7 = 212.5).

Head winds and tail winds must also be considered. When head winds are present, you should subtract the head wind from the airspeed. Tail winds should be added to the airspeed. For example, when the aircraft is flying north at 125 knots and the wind is blowing from the north at 10 mph, then the corrected airspeed is 115 knots (125 - 10= 115). When the air craft is flying south, then the corrected airspeed is 135 knots (125 + 10 = 135). The corrected airspeed must be used to find the ground speed, in feet.

For the time interval between exposures, the following formula should be used:

$$T = \frac{D}{S}$$

Where

T = Time in seconds

D = Ground-gained forward

S = Ground speed in feet per second

NOTE: When the interval between exposures can be accomplished in full seconds only, the tenths of a second should be dropped. By doing so, slightly more than the required 60-percent forward overlap is provided. This can be advantageous.

SCALE OF THE FINISHED MOSAIC MAP

The scale of the finished mosaic map is determined by using the following formula:

$$S = \frac{F}{12A}$$

Where

S= Scale

F = Lens focal length

A = Altitude

The answer derived by using this formula gives a representative fraction (RF) in like-units. Notice that you must convert the altitude to inches, since the lens focal length is normally in inches. For example, you used a 10-inch focal-length lens for a mapping mission flown at 5,000 feet. You can determine the scale of the finished mosaic as follows:

$$S = \frac{10}{12 \times 5{,}000}$$

$$S = \frac{1}{6{,}000}$$

The scale of the finished mosaic is 1/6,000 (1:6,000).

To reinforce the mission planning procedures, you can use the following example:

You are assigned to assist in the mission calculations required for a recon mapping mission. You are briefed on the mission and the following information is provided:

Area to be mapped is 10 nautical miles east and west by 20 nautical miles north and south.

Forward overlap required is 60 percent.

Side lap required is 40 percent.

Lens focal length is 12 inches.

Negative size is 9 $\times$ 9 inches.

True airspeed of aircraft is 140 knots.

The wind is from the north at 15 knots.

The scale of the chart used to plan and fly the mission is 1/50,000 (1:50,000).

The required scale is 1/12,000 (1: 12,000).

A graphic scale representing 3,000 feet is required on the printed mosaic map.

1. **Determine the altitude.** The first step in this problem is to determine the altitude at which the aircraft must fly to obtain the required scale of 1/12,000. The IFGA formula used to determine the altitude is as follows:

$$\frac{I}{F} = \frac{G}{A} \text{ or } A = \frac{FG}{I}$$

Since G (ground coverage) is not known, you must substitute the required scale (1/12,000) for it. At a required scale of 1/12,000, each unit of I (on the film plane) records 12,000 units of G. Since A is measured in feet, you must divide your answer by 12 to get the units in feet.

$$A = \frac{12 \times 12{,}000}{1} = \frac{144{,}000}{1} = 144{,}000$$

Divide by 12 to get altitude units in feet

144,000/12 = 12,000 feet

2. **Determine the ground coverage.** Now that you know the altitude at which the mission must be flown to obtain a scale of 1/12,000, you can determine the amount of ground coverage on each frame. Again, this information can be determined using the IFGA formula. Remember that the forward overlap required is 60 percent. The remaining 40 percent of the 9-inch negative is usable imagery for GGF. You must first find the size of the usable portion of the negative for GGF. This is accomplished as follows:

$0.40 \times 9 = 3.6$ inches of useable image area for GGF

$$\frac{I}{F} = \frac{G}{A} \text{ so } G = \frac{IA}{F}$$

$$G = 3.6 \times \frac{12{,}000}{12} = 3{,}600 \ \textit{feet}$$

The amount of side lap required is 40 percent. This leaves only 60 percent of the useable negative image area for GGS. You determine the usable portion of the negative for GGS as follows:

$0.60 \times 9 = 5.4$ inches of usable image area for GGS

$$G = 5.4 \times \frac{12{,}000}{12} = 5{,}400 \ \textit{feet}$$

3. **Determine the total number of frames required.** Next, you need to determine the total number of frames required to complete the mission. You know that the area to be mapped is 10 nautical miles east and west by 20 nautical miles north and south. Therefore, the strips will be flown north and south.

The number of exposures per strip is determined by dividing the GGF into the length of the map. First convert nautical miles into feet (1 nmi = 6,080 ft) and multiply by 20 (length of area to be mapped).

$6{,}080 \times 20 = 121{,}600$ feet

Next, divide by the GGF as follows: 121,600/3600 = 33.77 or 34 frames per strip. Remember to add four more frames. This totals 38 frames for each strip.

Now you must find the number of strips required. The area to be mapped is 10 nautical miles long. Calculate the number of strips as follows:

10 (nautical miles) $\times$ 6,080 (feet per nautical mile) = 60,800 feet

60,800/5400 (GGS) = 11.25 or 12 flight strips

Remember to add one strip, so a total of 13 flight strips is required.

To determine the total frames required for the mapping mission, you must multiply the number of frames required for GGF by the number of flight strips required as follows:

$13 \times 38 = 494$ frames

4. **Draw flight lines on the chart.** Your next step is to draw the flight lines on the chart used to fly the mission. The scale of this chart is 1/50,000.

To determine the distance between the plotted lines on the chart, you must convert the GGS into inches, and then multiply the GGS (in inches) by the scale of the chart as follows:

5,400 (feet) $\times$ 12 = 64,800 (inches) $\times$ 1/50,000 = 1.29 inches

The distance between flight lines on the chart is 1.29 inches apart. A multi-finger divider should be used to draw these lines.

5. <u>Determine the time interval between exposures.</u> To determine the exposure interval, first convert the aircraft speed to feet per second. The true aircraft speed is operating at 140 knots, but there is a wind of 15 knots coming from the north. Since the aircraft will be flying in a north and south direction, the wind factor must be taken into consideration. At this time determine the corrected airspeed in knots, then determine the airspeed in feet per second as follows:

1. Corrected airspeed.

a. Aircraft flying toward the north

Corrected airspeed (140 knots - 15 knots = 125 knots)

b. Aircraft flying toward the south

Corrected airspeed (140 knots + 15 knots = 155 knots)

2. To determine aircraft speed in feet per second, you must multiply the corrected airspeed by the conversion factor of 1.7.

a. Aircraft flying toward the north = 212.5 feet per second

b. Aircraft flying toward the south = 263.5 feet per second

To calculate the exposure interval, you must use the following formula:

$$T = \frac{D}{S}$$

T = Time in seconds

D = GGF (distance)

S = Ground speed in feet per second

By substituting the values, you can determine the exposure intervals as follows:

$$T = \frac{3600}{212.5} \text{ or } 16.9 \text{ seconds for aircraft flying toward the north}$$

$$T = \frac{3600}{263.5} \text{ or } 13.6 \text{ seconds for aircrafr flying toward the south}$$

6. Graphic scale. To determine what graphic scale represents 3,000 feet, you should use the IFGA formula as follows:

$$I = \frac{FG}{A}$$

$$I = \frac{12 \times 3000}{12{,}000} = 3 \text{ inches}$$

Therefore, 3 inches on the map represents 3,000 feet on the ground.

SAFETY

Whether you take photographs from the rear seat of a jet or from the open door of a helicopter, you must be checked out and become thoroughly familiar with the necessary safety equipment and applicable safety procedures. Before the flight, you should arrive at the aircraft or briefing area in sufficient time for the preflight brief. The main responsibility of the pilot is to fly you and your photographic equipment to the target, put the aircraft in position for photographing, and return to the base safely. The pilot knows the limitations of the aircraft and what procedures to follow in an emergency. Ask the pilot about emergency plans and FOLLOW this advice.

Aircrew personal protective equipment plays an essential role in the safety and survival of people flying in Navy aircraft. The equipment is designed to protect them from the elements and to provide necessary comfort for efficient mission performance. Its primary function is to protect a crew member against the environmental hazards. Different combinations of clothing and equipment are used to provide overall protection and comfort to an air crew member under various flight, emergency, and environmental conditions.

Aircrew protective equipment is designed to meet the stress of a combat environment and to provide fire protection and camouflage with various other escape and evasion design features. Emphasis is placed on developing materials and clothing assemblies to enhance an individual’s chance of survival and to minimize injuries in an aircraft accident.

Before flying in an aircraft, you must obtain the proper personal protective equipment specified for the type of aircraft in which you will be flying. The squadron-, intermediate-, or depot-level maintenance activities can provide you with the required equipment. YOU MUST NOT FLY WITHOUT THE PROPER EQUIPMENT and the equipment must fit you correctly. **Your life may depend on it.**

WARNING

Unauthorized modification or deviation from prescribed life support and survival equipment by individual crew members could create safety hazards. NATOPS *General Flight and Operating Instructions,* OPNAVINST 3710.7, specifies minimum requirements for such equipment and is supplemented by the naval air training and operating procedures standardization program for each specific model of aircraft. Peculiar configurations or modifications to life support and survival equipment are not authorized. Aircrew Survival Equipmentman (PR) who issue and maintain this equipment have no authority or responsibility to perform these actions, so do not ask them to do so.

During takeoffs and landings, your photo gear must be made secure within the aircraft, so it does not become a hazard. When your equipment consists of small items, such as a hand-held camera and exposure meter, hold them in your lap. Tie-down straps or passenger seat belts provide a means of securing bulky equipment. If you cannot find the means to secure your equipment on board the aircraft, request assistance from the plane captain or another crew member. During flights in a helicopter, keep all photo gear secure. This will prevent it from falling out an open door. It is a violation of federal law to drop objects from aircraft while in flight. When working in or leaning out of an open door or window in an aircraft, you should use a neck strap or wrist strap to secure your camera and other items.

During takeoff and landing, you should occupy a designated passenger seat. Once airborne and before you approach an open door, you must have a properly adjusted, securely anchored crew member's safety harness around your waist. The crew member's safety harness should be adjusted BEFORE TAKEOFF. Attach the snap hook of the harness to a tie-down ring on the deck of the aircraft. The tie-down ring should be about 3 to 4 feet from the open door. Never attach the snap hook to pipes, tubes, cables, or similar items. Place the harness around your waist and fasten the latch and link assembly. Pull the adjustment straps of the waist portion of the harness, so it fits snugly around your waist. Now adjust the length of the safety strap, so you can sit in the open doorway and still lean forward about 1 foot.

PREFLIGHT AND POSTFLIGHT INSPECTIONS

As an aerial photographer shooting hand-held images, your preflight inspection is concentrated primarily on your photographic equipment and your personal protective equipment.

You know what camera and equipment checks to make before every photo assignment. These equipment checks are particularly important in aerial work. In aerial work, more people are directly involved with the mission. As a minimum, there is the pilot, copilot, plane captain, and yourself. With the great expense and time involved in flying Navy aircraft, IT IS ESSENTIAL that you have your equipment functioning correctly. Equipment breakdowns may occur during a flight; however, it is your responsibility to be sure that the necessary equipment and materials for the mission are present and working properly.

Your personal protective equipment must be checked before each flight—your life may depend on it. Because of the many types and applications of personal flight safety gear available, you must get a professional check on the use of your equipment and an inspection as to size and fit of your equipment from a knowledgeable Aircrew Survival Equipmentman (PR).

The aircraft preflight inspection is the responsibility of the pilot. This is not to say, however, that you should not check those areas of the aircraft in which you will be directly involved during the flight. For example, does the door, window, or hatch open and close easily? Is the intercom system working? What about the tie-down ring to which you will hook your safety harness? Is it safe? Has the ejection seat safety pin been removed? Is the canopy clean? Is the oxygen system working?

Your postflight duties after a hand-held aerial mission include removing all your equipment from the plane and "housekeeping," such as straightening up seat belts and securing the intercom and oxygen systems. You and the pilot should also discuss the mission—how did it go? What went right? What went wrong? What could be done better next time to make the flight go better?

COMMUNICATIONS

The pilot must know your intentions. This means you must communicate with him before and during the flight. Remember, the pilot is not looking through the camera viewfinder. The pilot's view of the target, providing he can see it, is different from yours. You must direct the pilot into positioning the aircraft for the photography.

The noise level during the flight is high and voice communications are difficult at best, particularly in helicopters. Establishing a few hand signals with the pilot beforehand may prove very helpful during the mission-hand signals that indicate "there is the target," "move right," "left," "up," "down," "turn right," "left," and "steady, I am shooting" (fig. 4-23). In the air, a pilot has a better understanding of your needs with prearranged signals as compared to makeshift signals which may fail to be communicated correctly.

Communications between you and the pilot are essential. During the photo part of the flight, you should be in constant communication with the pilot. To get the best photographs, you must communicate to the pilot about positioning of the aircraft. Tell the pilot when the aircraft is too close or too far from the target and when the altitude of the aircraft is correct or not correct. If camera problems develop, let the pilot know. Long periods of silence cause the pilot to wonder what is happening in the photography area and whether the mission is going as planned. This is no time to be bashful or intimidated. Do not be concerned about talking too much.

COMPOSITION

Since hand-held verticals are made with the camera pointed straight down at the ground, photographic composition for vertical photography is straightforward. The person requesting the work tells you what to show in the picture. Then it is primarily a

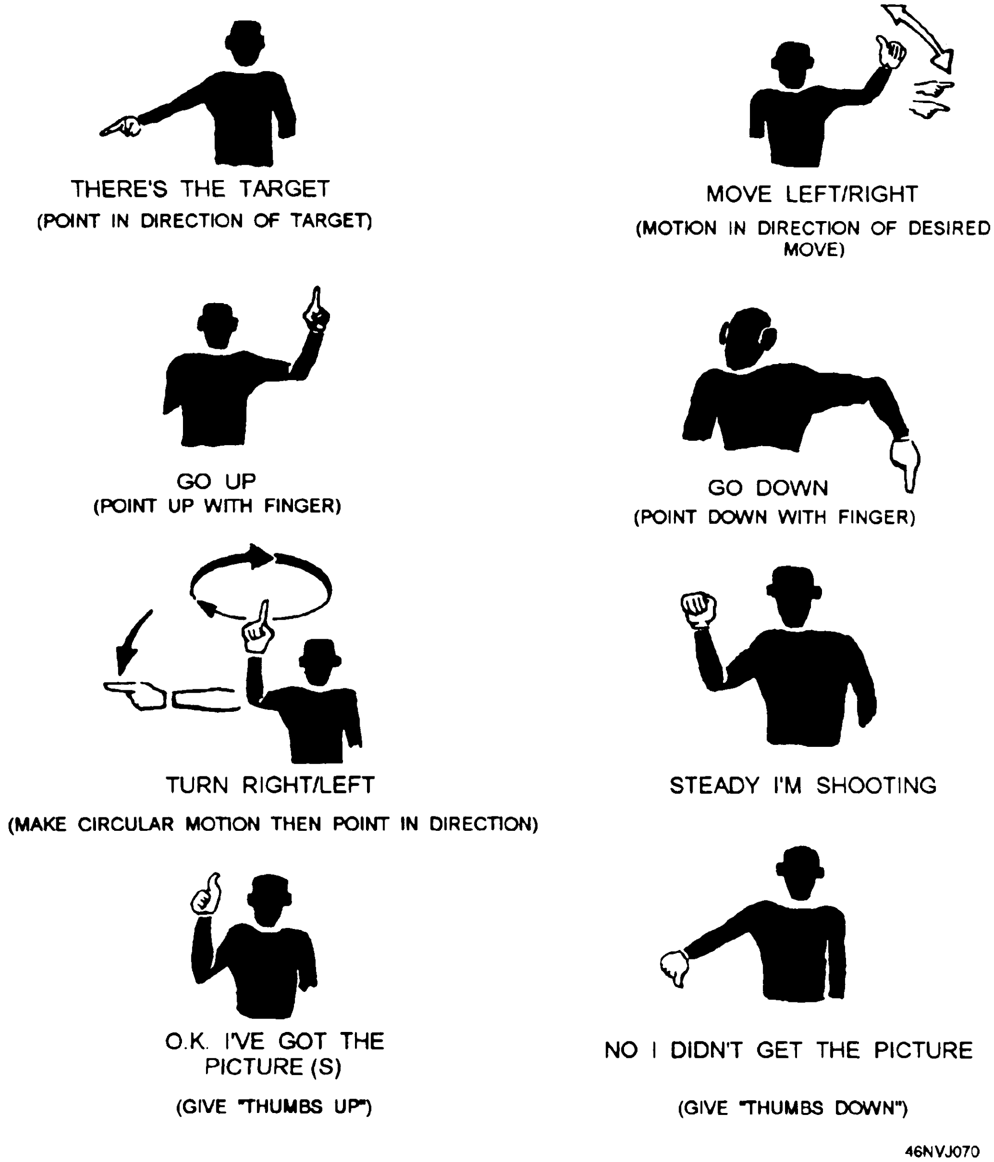


Figure 4-23.—Hand signals.

matter of including all of the subject or ground area in the picture.

Hand-held oblique aerial photography often provides a unique communication capability—an overall view that cannot be obtained from the ground in a single photograph or even in several photographs. Generally, aerial oblique photos show relationships in size and spacing between objects better than ground views. The angle of view is unusual and attention getting, partly because people are unaccustomed to seeing subjects from above. As with composition for any type of photography, when you compose an aerial photograph, you should consider all the aspects of good composition—image size, subject placement within the picture area, balance, camera angle, lighting, and timing (when to fire the shutter). The target and purpose of the pictures are the guides you should use for determining proper composition. Good aerial photographic composition is harder to achieve than ground photographic composition. In aerial work you are in a moving aircraft and do not have the time necessary to compose a picture in the viewfinder. You must compose the picture in your mind as you observe the target from the aircraft during the approach. You cannot move the subject around or change the direction from which the light is coming. Your two primary tools in aerial composition are camera viewpoint and timing. You must shoot your pictures at the correct instant to ensure the area and objects of interest are in the picture. Also, in a sequence of exposures (a strip), each photograph must have the correct relationship to the others in the sequence. In other words, you cannot have any "holidays" or missed areas within the strip.

You may have some control over what time of day to fly the mission. If so, use the sun to best advantage for the most desirable lighting. When the sun is at an angle that causes shadows to fall across the subject and obscure some important detail, you may ask to fly the mission at a different time of day or even on an overcast day. Whenever possible, shoot obliques with the sun falling on the scene from about a 45 degree angle. This provides proper shadows and creates a feeling of depth. With the sun directly in back of the camera, the picture appears flat. With the sun directly in front of the camera, the shadows may obscure detail and lens flare can result. Shadows play an important role in picture balance by creating an illusion of depth; they also aid in determining the physical characteristics of ground areas. The size of objects in a photograph can be determined by the length and width of their shadows. You can obtain the desired shadow effect by ensuring the pilot places the aircraft properly in relation to the target. Teamwork between the pilot and the photographer is another contributing factor to good aerial composition. Remember, both the photographer and pilot are "handling" the camera, but you are responsible for getting the images.

A minimum image size may be required to locate or identify large objects in a photograph. Small objects and great detail require a large image size. You can obtain the proper image size in your photographs by selecting the proper altitude of the aircraft and the lens focal length of the camera.

Subject placement within the image area is also an important consideration. Because you are in the air and have a "bird's eye" view of the subject does not mean you have a good camera viewpoint. Is a tall building or grove of trees hiding some important subject detail? If so, direct the pilot to move the aircraft into position for a better viewpoint. A good rule for composing low obliques is to divide the camera viewfinder into three sections: the first section at the bottom of the viewfinder is foreground, the center third of the picture is target area, and the top third is background. For high obliques, divide the camera viewfinder into four sections: the bottom section of the viewfinder is filed with foreground, the next section above it is target area, the third section is background, and the last quarter is sky. Subject balance should also be considered while keeping in mind the three or four primary divisions or areas of low and high obliques, respectively. Study the view during your approach to the target.

The horizon is another factor for consideration in oblique work The horizon or, in the case of a low oblique, the imaginary horizon should be straight in your pictures. A real horizon that is crooked, even in a high-oblique picture, does not appear natural; it is distracting and does not reflect the work expected of a professional aerial photographer. When making obliques, you should hold the camera so the horizon is straight. This is easy to do in a high oblique because the horizon is included in the picture and can be seen while the picture is taken. When making a low oblique, hold the camera as though a high oblique was being made, straighten the horizon, then lower the camera carefully to the correct angle for the low oblique. A horizon that is crooked is often the result when a photographer concentrates on the subject alone and does not compose the image in the viewfinder.

The camera may be tilted in some instances; for example, when two points of interest must be included in one exposure. If you cannot do this by holding the camera level, then turn the camera slightly at an angle; the two points can sometimes be included in the diagonal of the picture area (fig. 4-24).

Figure 4-24.—Tilting the camera to include subject area.

Figure 4-25.—Missiles used to frame the F-14 Tomcat.

SHOOTING TECHNIQUES

Your camera equipment should be prepared for the aerial assignment well before you approach the target area. As you approach the target area, you should recheck your equipment and have it ready for the first exposure. Check the altitude, speed, and direction of the aircraft. Check to see that you have the right camera angle for the best picture. Using voice communications or prearranged hand signals, direct the pilot to fly the aircraft into the best picture-taking position. Directing the necessary turns enables you to get the aircraft into proper position without a lot of explanation to the pilot.

Whenever possible, decide on the altitude you want to fly before takeoff. When the subject requires photography from different altitudes, start at the highest level and work your way down. Thus time en route to the target can be used for climbing. Altitude can be reduced much faster than it can be gained.

When an aircraft is turning to take up another heading, the wing or rotor blades may obscure the subject. Ask the pilot for precise, steep turns; this technique will blind you to the target for only a few seconds.

Do not shoot photographs when the aircraft is turning. This causes your negatives to be reasonably sharp in the center, but decreasingly sharp toward the edges. High-shutter speeds may not correct this fault.

One of the principal problems in hand-held aerial photography is camera movement during exposure. This basic problem is magnified significantly where aircraft vibration and relative target movement are also present. Best picture results can be achieved when the pilot reduces the throttle. This reduces aircraft vibration and minimizes image movement. Image blurring, caused by camera movement, can be reduced by using a faster shutter speed. You must handle the camera carefully to reduce the effects of aircraft vibration transmitted on the camera. You should firmly grip the camera with your elbows held firmly to your sides. No part of the camera or your upper body should touch the aircraft while exposing film. At the instant of exposure, you should hold your breath. The shutter should be depressed in a steady, smooth manner. You

Figure 4-26.—Air-to-air photograph taken through a closed canopy.

may also be able to minimize image motion by panning the subject with the camera. When you are flying low, the target may "shoot" past you so fast that the shutter speed cannot "stop" it. This results in a photograph that is not sharp. To prevent this, "follow the target" (pan) with your camera. The pan must be continuous and smooth. Move the camera in the direction opposite to the direction of flight, keeping the lens fixed at some point on the target. With this technique, the image on the film does not move as much as it would if the camera were held still.

With a hand-held camera, you have freedom of movement; however, the view of the camera is limited by the structure of the aircraft. Do not include the tip of a wing or any other part of the aircraft in your photographs, unless you do it intentionally (fig. 4-25). The views of the target are best when the aircraft is approaching or leaving the target and the target is off to one side. At a level altitude, in fixed-wing aircraft, you may have difficulty excluding the tip of the wing from the view of the camera. You can tell the pilot to bank the aircraft; that is, raise the wing of a high-wing aircraft on the side from which you are shooting. You can also tell the pilot to lower the wing of a low-wing aircraft when the aircraft passes the target. This maneuver should lift or drop the wing of the aircraft out of the picture area. Another flight maneuver for getting the wing of the aircraft out of the picture is to have the pilot crab the plane. After the plane is crabbed, it is on a different heading than the original direction of flight; thus the wing is outside the area of the photography.

When you are shooting photographs from a helicopter, have the pilot fly at a level altitude or bank when the aircraft passes the target, so the rotor blades are raised from the area of the photograph. This minimizes the chance of rotor blades appearing in the photograph.

The slipstream outside an aircraft can be very strong, so when you are taking photographs through an open window or door, be sure you have a good grip on the camera and all loose objects, and camera parts are well-protected and secured.

In some aircraft, you must take photographs through a canopy or closed window (fig. 4-26). The plexiglass, or glass, can cause a slight shift in image focus. This shift in focus may be reduced by stopping down the lens; however, this is not always possible because you may need fast shutter speeds. The best method of shooting photographs through a window is to take the picture with the optical axis of the lens perpendicular to the surface of the window. The lens should be as close as possible to the surface of the window without touching it. Although this method allows you to take only one or two photos during each pass of the target, the quality and definition of the image is better. When shooting photographs with an SLR camera through a window or canopy, you will find it helpful to make a foam rubber "doughnut" about 2 or 3 inches thick. This foam rubber shield should be taped to the camera using surgical tape because it sticks well and can be removed without leaving a gummy residue. After attaching the foam rubber shield to the camera, you should place it against the aircraft window to block internal reflections from that part of the window that the camera "sees." The shield also absorbs vibrations from the window.

Most of your hand-held aerial work, both oblique and vertical, consists of single shots; however, you may have to fly oblique and vertical strips that require overlapping photographs. The camera-to-scene distance must remain constant while you are shooting the strip. Changes in distance cause the image size to change and make matching the adjacent exposures impossible. You should make the exposures at regularly spaced intervals. You can determine the time interval visually between the exposures for a strip. Before the flight, mark your viewfinder to show the distance an object must move in the viewfinder to move the image 40 percent of the width of the film. During the flight, make the first exposure, hold steady, and make the second exposure after some point in the scene has moved the distance marked on the viewfinder. The marks are the same for any aircraft speed or altitude.

When you are not using an SLR camera, change the marks on the viewfinder if you change either the film format or the focal length of the lens.

Hand-held vertical photography is easiest from helicopters. You can lean out from your sitting position on the floor or from a passenger seat and hold the camera with the proper attitude for taking verticals. You should hold the camera firmly in your hands, keeping your torso relaxed so your arms will act as vibration dampers. Using this method, you can take vertical aerials that are incredibly sharp because of the maneuverability of the helicopter, its capability for slow flight, and the possibility for both the pilot and the photographer to see the target. Because of these features, accurate vertical photography is easier from helicopters than from fixed-wing aircraft.

Most air-to-air photography you shoot will be of other aircraft. The purpose is to produce display and public affairs (PAO) photographs. You may also be assigned to take air-to-air photography for research and testing purposes. When shooting air-to-air photographs, you should maintain voice communication with both the pilot flying your aircraft as well as the pilot(s) of the aircraft you are photographing. This provides an opportunity for you to direct all the aircraft involved into position for photographs.

Generally speaking, the best air-to-air photographs are made from slightly above, to the side, and slightly forward of the plane being photographed; however, you should try other views, such as from below or slightly aft of the subject aircraft. A longer than normal focal-length lens (80mm or greater for a 35mm camera) should be used when you are photographing only one or two aircraft at a time. Longer focal-length lenses prevent distortion that results from using a normal or short lens. With a normal or short lens, the wings that stick out from the fuselage of the target plane and the long nose or tail section appear distorted when you photograph them from close range. When shooting formations of three or more aircraft, you should use a normal focal-length lens because you are farther from the subjects and distortion is not a problem. For a head-on view use a long focal-length lens and have the pilot fly the aircraft you are in across and above or below the projected flight path of the plane being photographed. Of course, each of the pilots need plenty of room to avoid a mid-air collision. A better and safer way to get a head-on shot is to fly in front of the plane being photographed, in the same direction, and at the same speed. You can take this shot from the open ramp of an aircraft, such as a C-130 or CH-53. In aircraft such as these, you can stand at the edge of the open ramp; ensure that you are secured properly with a safety harness.

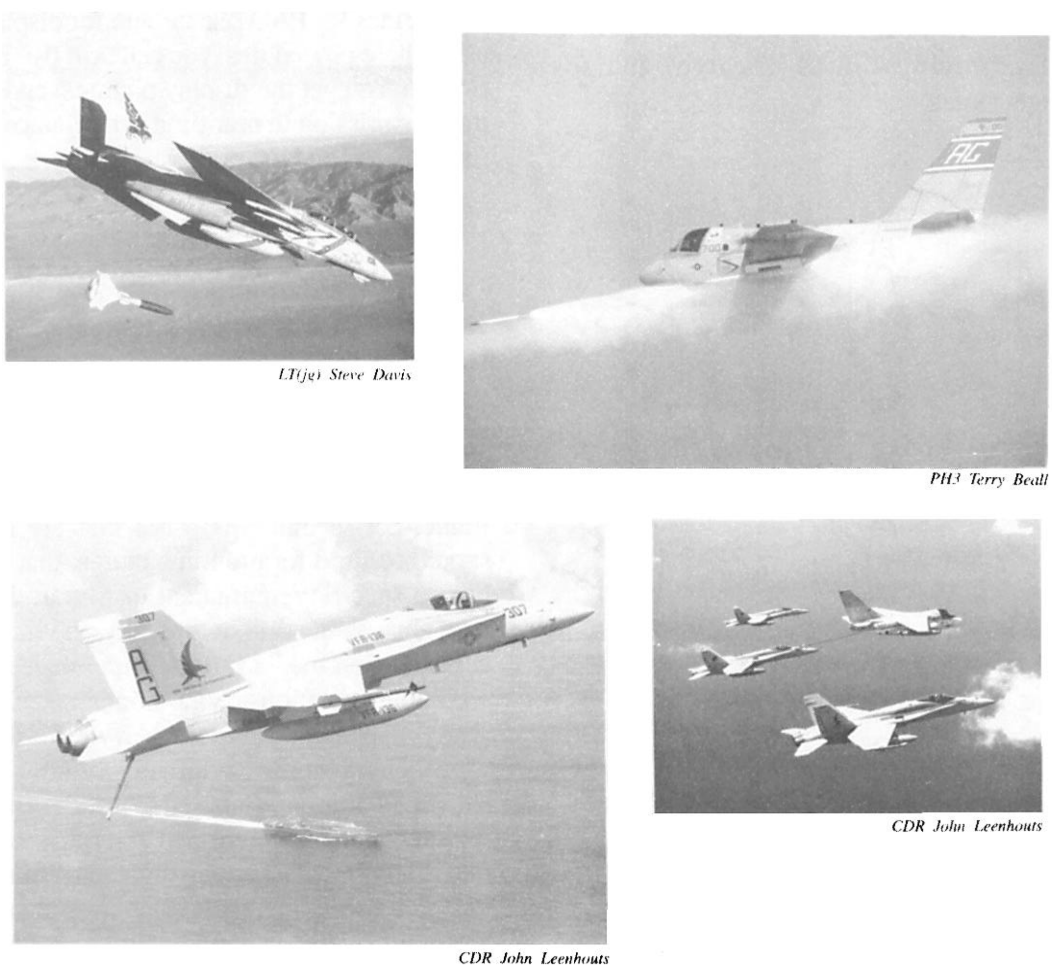
The aircraft you are photographing does not always have to fly straight and level. Good, interesting pictures can be taken while aircraft are maneuvering, such as in a long, slow turn or in a bank. When the underside of the fuselage must be shown, request the pilot of the target aircraft to roll the plane, so the sun shines on the underside of the aircraft. For this shot, the plane containing the photographer should fly in a bank above the subject plane. This maneuver provides you with a camera angle looking down on the plane to be photographed. When shadows are not a problem and enough light is reflected on the fuselage of the aircraft being photographed, the plane with the photographer can fly under the other aircraft and take photographs while it is in straight and level flight.

When shooting pictures of aircraft formations, you should be sure the spacing between them, as seen by the camera, is uniform. Navy pilots are among the best in the world. They can fly their aircraft in tight formations with near perfect spacing between them; however this may not be perfect as the camera "sees" it. Remember, what the camera "sees" is the way the picture will look (fig. 4-27).

The pilots of the aircraft you are photographing will probably look at the camera while you are taking their picture. Go ahead and let them—for one shot. Then tell them, "I have your picture, and I'll be sure you get a copy of it; but for the rest of the mission, please do not look at the camera." When the pilot is looking into the camera, it looks unnatural and distracts from the main subject—the aircraft.

MARITIME SURVEILLANCE PHOTOGRAPHY

Maritime surveillance data gathering for intelligence purposes is assisted by photographic methods; that is, high-quality pictures to provide permanent records so that detailed interpretation of the collected data can be made. A camera can record full details of the target instantly. Photographs should be made of all maritime targets worthy of observation including surface ships (war and cargo) and submarines. Air reconnaissance photographs of surface and subsurface targets made from fixed-wing aircraft and helicopters add greatly to the complete intelligence data on enemy or potential enemy shipping. It is often the duty of the Photographer's Mates to obtain this type of photography by using a hand-held camera.



LT(jg) Steve Davis

PH3 Terry Beall

CDR John Leenhouts

CDR John Leenhouts

Figure 4-27.—Air-to air photographs.

The value of maritime surveillance photography can be enhanced if you use correct photographic composition, appropriate field of view, and proper rigging patterns (fig. 4-28). The best photographic composition of a ship cannot always be obtained by shooting horizontal views. In maritime surveillance photography, it is important for you to ensure the target is recorded as large as possible on film.

Four basic rigging patterns for maritime surveillance photography arc in use today. They are the Special Interest Rig, the Quick Rig, the Normal Standard Rig, and the Full Rig. Proper rigging of the target provides maximum intelligence data from the photographs. To better understand the purpose of each rig, you must know what each view (or point) of the rig is designed to achieve. The BOW QUARTER view is useful in determining forward deck cargo-handling equipment, electronic arrays, and vessel identification. The BEAM view provides the length of the target plus the stack and antenna height. The STERN QUARTER and the STERN views are used to determine cargo and electronic arrays on the aft section of the vessel. The VERTICAL view is valuable in locating electronic arrays, in determining full-deck cargo, and for measurement purposes.

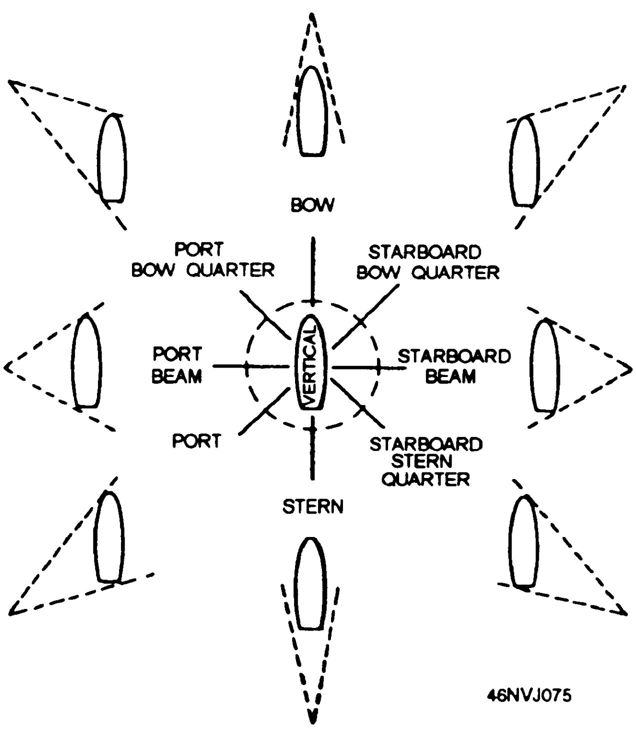


Figure 4-28.—Maritime surveillance photography rigging patterns.

The SPECIAL INTEREST RIG is required when a particular vessel is photographed for the first time, or there are specific areas of interest on a particular vessel. Before this type of mission, a special briefing must be conducted to determine what specific rigs should be flown to satisfy mission requirements. The QUICK RIG is used for routine photographic documentation of a contact (vessel) observed while on patrol. The quick rig consists of the bow quarter, beam, and stem quarter views of a vessel. The NORMAL STANDARD RIG, commonly referred to as the FIVE POINT RIG, consists of the bow quarter, beam, stem quarter, stem, and vertical views of a vessel. This rig is used to provide a more detailed representation of a vessel. The FULL RIG, or NINE POINT RIG, is required when enemy or potential enemy vessels are being photographed. This rig provides complete coverage for all the areas of interest. The best approach for rigging most of the aircraft used in maritime surveillance photography is from the bow of the target.

Although the previous discussion concerns obtaining intelligence photography, the very same procedures are useful in shooting pictures of ships and submarines for PA0 release and for display prints. By using these procedures, you can "kill two birds with one stone." You get the display pictures, and it serves as a training mission in maritime surveillance photography for both you and the pilot.

MOTION-MEDIA PHOTOGRAPHY FROM THE AIR

In most cases, the techniques and exposure recommendations for still aerial photography apply to shooting motion-media photography from the air. However, there are a few differences. As a general rule, frames-per-second (fps) rates that are above normal should be used for motion pictures; that is, unless you have a specific requirement to film at the "real time" rate. Just as in still photography, the image quality of aerial motion media suffers from image motion on the recording. Motion-media scenes taken from aircraft always appear much faster when viewed than when they were being recorded originally. Aerial movies when shown at normal frame rates are disturbing to the viewer. There is no hard-and-fast rule about what frame rate is appropriate for viewing; there are several factors that play a significant role, such as speed and altitude of the aircraft. A general rule of thumb is to use about one and one half or twice the normal frame rate: 32 to 48 frames per second for 16mm and 24 to 36 frames per second for super 8. For video work, the shutter speed should be set to 1/500 second or higher.

When shooting, you must keep the camera steady, keep your upper body and the camera from making contact with the aircraft, and make any necessary pans slowly and smoothly. Fixed-wing aircraft should make a gentle arc around the subject (into the wind) at moderate speed and with a few degrees of flap. On occasion, you may be filming a fast-moving activity on the ground. Again, the technique of flying an arc around the subject is often best because you are moving faster than the action below. You need a zoom lens or a camera with a turret and different focal-length lenses to change your view of the subject. However, avoid the temptation to overuse the zooming technique while shooting. Instead, change the focal length between scenes to obtain variety and interest in your images.

The problem of maintaining a steady image is greatly magnified when you must shoot with a long focal-length lens. In these circumstances, you should use a gyrostabilizer, if it is available. A gyrostabilizer is an aerial camera mount that uses a gyroscope to maintain camera stability.

PROCESSING AERIAL FILM

Because of the cost involved, the importance or urgency of the images, and the situations involved in obtaining aerial images, it is extremely important to process images under optimum conditions and the images be free of physical or chemical defects.

Film processors must be checked and verified according to the quality-assurance procedures established by your imaging facility. Processing solutions, machine speeds, and temperatures must be checked with sensitometric tests and verifed to comply with the processing instructions indicated on the mission planning form. Each aerial film-processing work center should have an established family of curves for each type of film used. Camera exposure settings are based on the expected response (speed) of a particular emulsion developed to a specified gamma in a particular type of chemistry at a specified temperature. If you deviate from the planned processing parameters, it affects the degree of development of the imagery and may render the imagery unusable. The photo processing crew is the key to success or failure of the entire reconnaissance mission.

MISSION PLANNING FORM

The mission planning form (fig. 4-29) is used with TARPS. It is a tool of communication between the reconnaissance coordinator, squadron maintenance personnel, and imaging facility personnel. The form is divided into three basic areas of responsibility: mission data, maintenance, and processing data. The section of primary interest to you is the mission data and processing data.

Mission Data Section

After reconnaissance mission requirements are established, the sensor or group of sensors best suited to fulfill the requirements are selected. The mission planner should enter the sensors, the appropriate sensor IDS, the types of film, and the processing gamma of the types of film. The mission planning form should then be forwarded to the aircraft maintenance personnel and to the photo personnel. This data may then be used to equip the aircraft for the mission. The data also allows the imaging facility to make preparations for processing the film.

Maintenance Section

After receiving the mission planning form, the line maintenance personnel begin preparing the sensors, associated equipment, and aircraft for the mission. As various tasks are completed, the Maintenance section of the form is completed by maintenance personnel. When the aircraft returns from the mission, the film is removed, and the appropriate postflight counter settings are entered in the Maintenance section of the form by maintenance personnel. The film, along with the mission planning form, is then delivered to the imaging facility for processing.

Processing Data Section

The film is processed according to the information entered in the Mission Data section of the form. The film processing results are entered in the Processing Data section of the form. The film is then evaluated for image quality and appropriate entries are also made in the Processing Data section of the form. Finally, the completed mission planning form is returned to the reconnaissance coordinator for purposes of debriefing and filing.

MISSION PLANNING FORM

PHOTO LAB JOB CONTROL INFO

CLASSIFICATION 01	PROJECT NUMBER 02 05	UNIT 07 — NUMBER 09 — MEDIA 14	O R 16

REQUESTER SUPPLIED INFORMATION ORGANIZATION	NAME OF REQUESTER	UIC 17	CUSTOMER JOB NUMBER 22

PHONE	AUTOVON PREFIX	RECEIVED	DATE 45 — 47 — 50

PILOT	RIO	EVENT	ETD	AC	POD	FLT TIME

DATE (DAY MONTH YEAR)	MISSION	SQUADRON	DET	SORTIE

MISSION DATA

SENSOR DATA	FRAME CAMERA	PAN CAMERA	IR SENSOR		
FILM TYPE					
FILM LOAD					
S/C					
FILTER					
DDS EXP/PW	1-2-3-4-5	10-15-20-25	1-2-3-4-5		
GAMMA					

REQUIREMENTS SET BY DAY-TIME

MAINTENANCE

CAMERA NO.					
MAGAZINE NO.					
SUPPLY NO.					
TAKE UP NO.					
EMULSION/TYPE					
PRECOUNT					
POSTCOUNT					

LAB DELIVERY BY DAY-TIME I.D. NUMBER

PROCESSING DATA

PROCESSOR NO.					
CALIBRATED FPM					
TEMP					
DEVELOPED GAMMA					
QUALITY OF FILM					
FOOTAGE					
DAY/TIME					
PROCESSED BY					

FILM PICKED UP BY DAY-TIME

REMARKS

46NVJ076

Figure 4-29.—Mission planning form

PROCESS EVALUATION

Pre-mission validation must be performed on the processing system before attempting to process mission material. These tasks must be performed so the system is operating within acceptable, established limits for that particular mission. Six tasks must be performed as follows:

- The processing machine must be checked and verified to be operating correctly. This includes solution levels, transport system, temperature, replenishment rates, and water supply.

- The measuring equipment, such as densitometers and pH meters, must be calibrated properly to ensure valid, reliable data.

- The processing, printing, and support equipment must be checked and verified to be operating properly.

The composition of chemical solutions must be verified to be correct before processing mission material.

- The sensitometric properties of photographic materials must be certified to be within established standards.

- A scratch test must be conducted to ensure all the rollers are operating properly and none of the guides are out of adjustment.

Once the pre-mission validation is complete, you are prepared to process the actual mission material. Before processing the film, you must attach a leader tab to the roll of film. The leading end of the film must be cut straight before splicing it to a leader tab. A piece of 7-mil Estar base film may be used as a leader tab. Processed X-ray film works well also. The leader tab should be about 12 inches long and cut to the same width as the film being processed (except when used to lead a control strip).

Mission processing includes the following procedures:

- Protect the material being processed from dirt, dust, condensation, and other solutions, such as oil and water.

- Avoid applying excessive force to the surface of the film; abnormal stress can cause pressure sensitization.

- Inspect the material being processed for physical defects before machine processing. Defects, such as tears, crimped film edges, and defective splices, can cause the film to jam in the processor.

- Ensure the film is processed in a processor that has been certified beforehand.

- Monitor the processing temperatures and the transport and replenishment rates while the film is being processed.

- Monitor the film exiting the dryer for correct dryness, possible defects, and image quality.

- Follow the instructions concerning the storage of film (before and after exposure) carefully.

POST-MISSION IMAGE EVALUATION

After processing, the mission film is subjected to stringent post-mission evaluation for the following reasons:

- To determine whether or not the process met desired sensitometric goals and to provide feedback for process adjustment

- To reveal improper procedures or techniques and to identify defective materials

- To identify malfunctioning equipment

The post-mission evaluation should include three phases: image quality, image analysis, and laboratory evaluation.

Image Quality

The mission film must be inspected for defects, such as fogging, streaking, pinholes, and shadows. These defects are caused by foreign matter in the camera or on the aircraft window from which the photographs were taken.

You should also look for superficial defects, such as film tears, dirt, scratches, abrasions, or foreign marks. Defects found should be described and reported as to the actual frame position to help identity the cause, such as improper handling, processing, or other lab or maintenance procedures.

Image Analysis

Image analysis consists of density measurements made with a densitometer. The properties to be evaluated should include D-min, D-max, density range, and gross fog.

Laboratory Evaluation

Whenever possible, you should use samples of unexposed sensitized materials from the mission to produce sensitometric measurements and standards. This data should be used for comparison with the mission film after processing.

POST-MISSION MAINTENANCE EVALUATION

Photographer's Mates working in the Aerial Processing section must be able to supply accurate maintenance feedback information to the reconnaissance system maintenance crews. Since the end results are a true measure of system performance, this feedback will do the following:

- Ensure that maintenance personnel become aware of possible system malfunctions.
- Aid in evaluating overall system performance.

The process of evaluating a photographic negative to determine system defects, as related to overall performance, is one of the most complete measures of system output. System defects noted during film evaluation should be recorded on a film maintenance feedback form and forwarded to maintenance personnel for action.

Frame Spacing

On all serial-frame camera imagery and panoramic camera imagery, you should include a space between each exposed film frame. While the space may differ in width requirements, it should be present. Frame spacing defects generally indicate that a system defect exists, such as a fault in the film-advance mechanism.

Image Overlap

Image overlap between successive frames provides stereo viewing capability and distortion-free imagery for a mosaic.

Instructions by the camera manufacturer contain tables with overlap specifications for serial-frame cameras and panoramic cameras. If the overlap is not met, the camera may be receiving an improper V/A (velocity/altitude aboveground level) signal from the system. In addition to improper overlap, this problem can cause blurred images.

Data Block

Each frame contains a data block and other pertinent information about the mission, such as film and flight direction, frame count, and so forth. In an infrared reconnaissance set (IRRS), the data block is usually recorded along the length of film periodically. Discrepancies in the image of the data block are usually caused by a malfunction within the sensor (camera or IRRS).

Static

When film loses or gains electrons (negatively charged particles), the film becomes either positively or negatively charged. This charged material seeks to return to a neutral state by transferring electrons from or to other objects. This transference can sometimes cause heat and light. When light occurs, it fogs unprocessed film emulsions and causes markings on the processed film. These markings may have a spider web or lightninglike appearance.

Shutter Banding

Banding is associated with focal-plane shutters. It is caused by defective shutter operation. Banding can be identified by the presence of uneven illumination streaks across the line of flight. This defect is caused by the focal-plane shutter slit, varying in size, and an erratic shutter curtain or erratic film transport through the focal plane during the exposure cycle.

Camera Light Leak

A camera light leak is often difficult to recognize. It can cause various nonimage-forming shapes and appear and disappear as the angle of light to the leak changes. The light leak causes areas of the film to become fogged.

Exposure

A negative that has detail in both the shadow and highlight areas is exposed properly. However, when evaluating the negative image, it is necessary to consider the subject matter because less exposure is required for light sandy beaches and snowcovered terrain and more exposure is required for dark terrain, such as forests and industrial sites.

When you are viewing a negative that has been exposed normally, patches of snow or light beach scenes appear overexposed. Inversely, patches of dark terrain or industrial sites appear underexposed. When the negative is completely underexposed or overexposed, the film sensitivity or filter factor (S/C) was set incorrectly or the automatic exposure control (ABC) in the camera system malfunctioned.

Vacuum

The lack of adequate vacuum in a serial-frame camera permits the film to sag away from the focal plane, causing the image to be blurred. The most common indication of insufficient vacuum is crooked data blocks.

Miscellaneous Defects

Reflections from the camera window of the aircraft, depending on the angle of the sun in relation to the window, can cause flare (nonimage-forming exposure) of the film.

Condensation on a camera lens can result in a halo effect surrounding film image points. This is generally caused by rapid aircraft descent immediately before a photo run.

AERIAL DUPLICATION

Two methods of producing high-quality reproductions of black-and-white aerial film are in use today. One method is the specific tone reproduction method. The second method is simpler and more feasible for shipboard use, so it is discussed in more detail in this chapter. This method is called the trigradient tone reproduction method or the 1.00 print gamma method.

The following criteria is recommended as a guide to optimum photographic quality and product uniformity in producing duplicate positives or negatives from original aerial negatives. The overall objective of these recommendations is to ensure that a maximum amount of intelligence information is retained in an optimum form.

- Only the straight-line portion of the characteristic curve of the duplicating or printing material must be used. For most duplicating film, the straight line lies between densities of 0.40 to 1.80. Thus the D-min should be close to 0.40 and the D-max should be no more than 1.80 in the duplicate.

- Normally, the contrast of the duplicate is correct when the density range between the D-max and D-min falls between 0.80 and 1.20, preferably near 1.00.

The requirement for using the straight line is met when the exposure level of the printer is correct. The contrast requirement is met when the processing is correct. Specifically, the contrast of the duplicate can be increased or decreased relative to the original by increasing or decreasing gamma, respectively. To achieve these goals, you must use some form of tone control to guide the printing and processing operations. The duplication of aerial reconnaissance imagery requires that exacting standards and controls be stressed. This helps to ensure that the imagery is of the highest quality.

SPECIFIC TONE REPRODUCTION METHOD

The purpose is to match the characteristic curve and the density range of the original negative to the characteristic curve of the duplicating material being used.

TRIGRADIENT TONE REPRODUCTION METHOD

The trigradient tone reproduction method of duplicating is an objective method for determining printing and processing requirements. This method allows you to select one of three standardized processes. Each process produces a different contrast or gradient. The processing requirement is selected by determining whether the density range of the duplicate should be increased, maintained, or decreased. By doing so, you can alter the density range of the imagery, if necessary, in each generation. Thus the density range of the final product conforms closely to the desired tonal values (based on a D-min of 0.40).

Trigradient Control Curves

As stated previously, the trigradient tone reproduction method is based on three tone-control curves (or printer curves): high contrast, medium contrast, and low contrast.

Basically, the printer curves are produced the same way that sensi-strips are made for process monitoring. Instead of using a sensitometer to expose the film, the contact printer is used to expose the film through a step tablet. Since the amount of exposure is unknown, the horizontal axis of the curve indicates the density of the step tablet. The vertical axis represents the density produced after the duplicating film is exposed through the step tablet and processed.

Each set of printer curves consists of a family of response curves that graphically display the various tones produced in the duplicating material when it is printed under various exposure and processing conditions. Each curve is labeled with the exposure setting used on the printer to create the curve (figs. 4-30, 4-31, and 4-32). These response curves enable the density range of the imagery to be altered, so the density range of the final product conforms closely to the desired density range (1.00). The exposure of the printer is important since it determines the placement of the tonal values of the imagery being reproduced on the sensitometric response curve of the duplicating material. Ideally, all tones should fall on the straight-line portion of the response curve to ensure that the images are reproduced uniformly. The D-max of the imagery being duplicated is used to determine the required exposure since it reproduces as the D-min in the reproduction.

Trigradient Tone Reproduction Procedures

The following procedures are used in the trigradient tone reproduction system:

1. Obtain the three sets of tone control curves (high, medium, and low contrasts) for the particular duplicating materials being used.

2. Determine the D-max and D-min densities on the roll of imagery to be duplicated. Remember, the D-max and D-min are the areas in which you want to retain detail, not necessarily the areas of highest and lowest density. Do not use specular highlights or completely black areas to represent the D-max and D-min.

3. Determine the density range in the original, and determine whether the tonal range should be increased, retained, or decreased. Do this to obtain the desired density range (usually 1.0) on the duplicate.

4. Based upon results of step 3, select the set of response curves closest to the density range (high, medium, or low).

5. On the horizontal axis, locate the density of the step tablet that corresponds to the D-min density that you selected. Go up from this point until you intersect the 1.40 line and draw a tick mark.

6. On the horizontal axis, locate the density of the step tablet that corresponds to the D-max density that you selected. Go up from this point until you intersect the 0.40 line and draw a tick mark.

7. Using a straightedge, select the characteristic curve closest to your straight line. If the curves cross, choose the curve closest to your D-max because this density controls the exposure of the D-min on the duplicate.

8. Expose and process the duplicate film according to your determination in step 7.

9. Read the D-max and D-min of the duplicate film. If these values are not within established tolerances (0.05, for example), another duplicate must be made. Minor adjustments in exposure or processing may have to be made. For example, if the D-min is too high, then less exposure is required. If the D-min is within tolerance but the D-max is too low, then more development is required (to raise the contrast).

The entire tone control system is based upon data produced when the system is established. For the system to be accurate and reliable, all of the major variables must be controlled so they can be carried out on a repetitive basis.

CAPTIONING AERIAL PHOTOGRAPHY

Captioning and slating hand-held aerial photography is as important as captioning and slating still and motion-picture photography that is taken on the ground. In captioning aerial photography, however, the caption information should be expanded to include the camera lens focal length, the altitude, and the direction of the aircraft from which the picture was made and the time of day the photograph was taken.

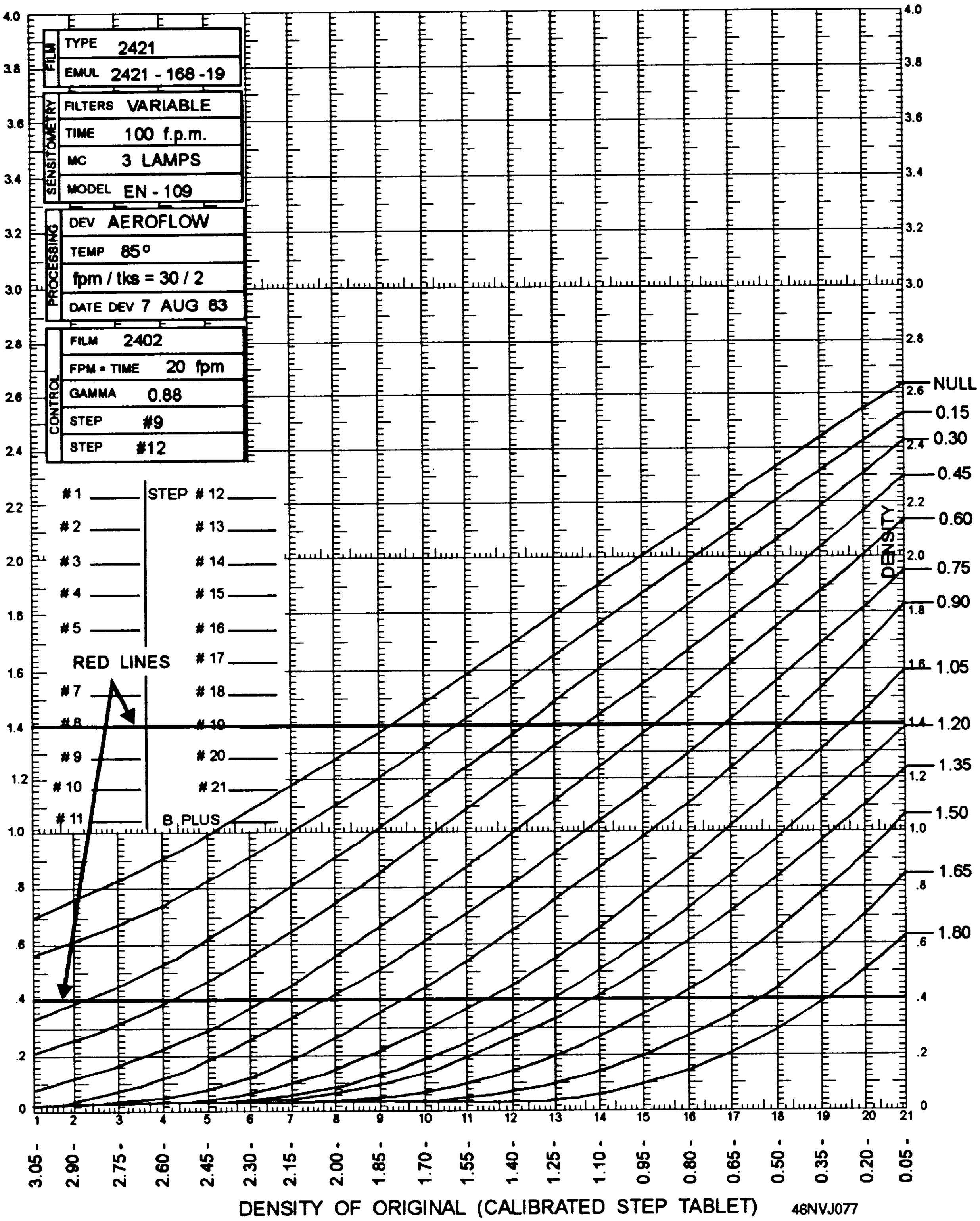


Figure 4-30.—Low-contrast printer curves.

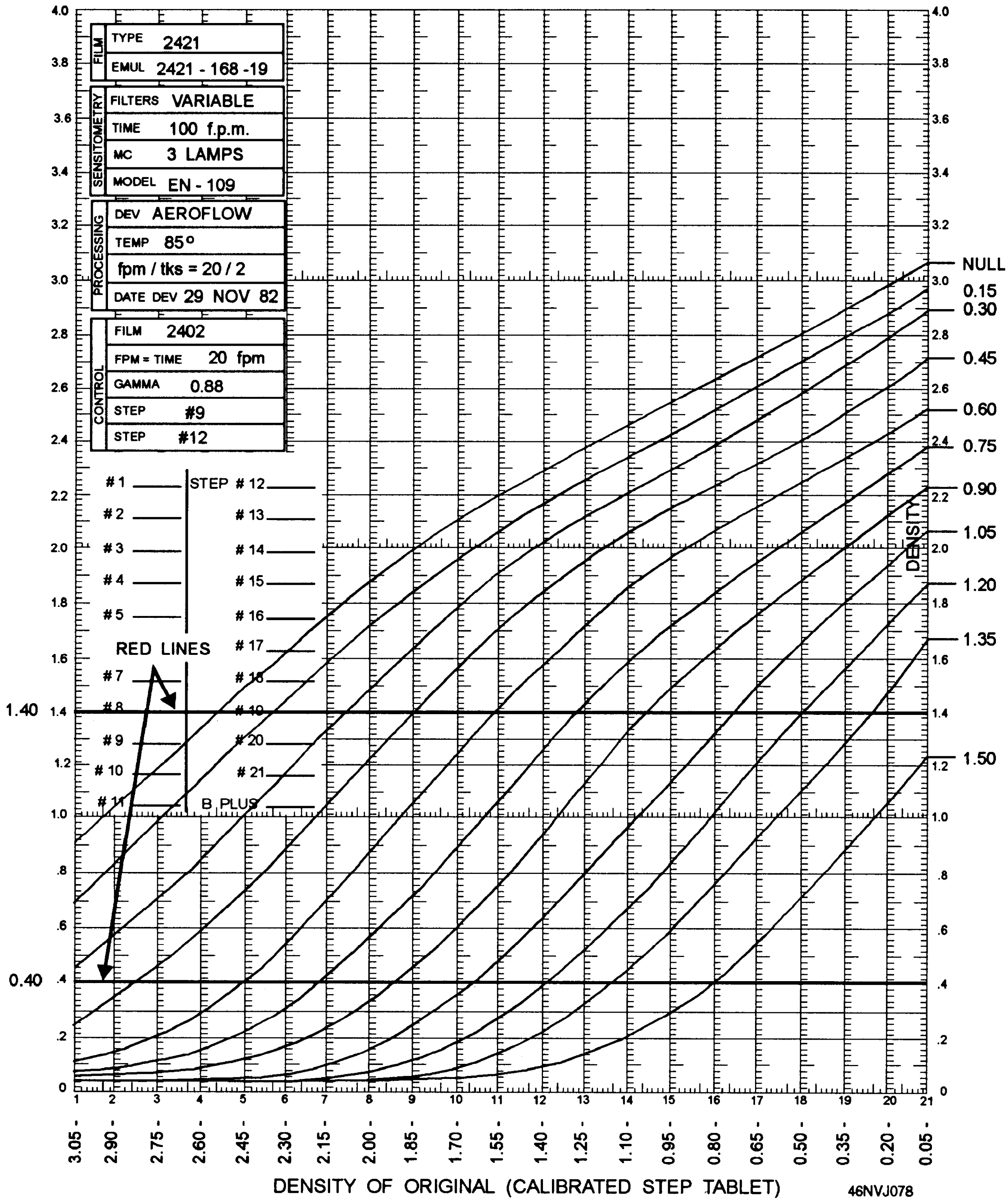


Figure 4-31.—Medium-contrast printer curves.

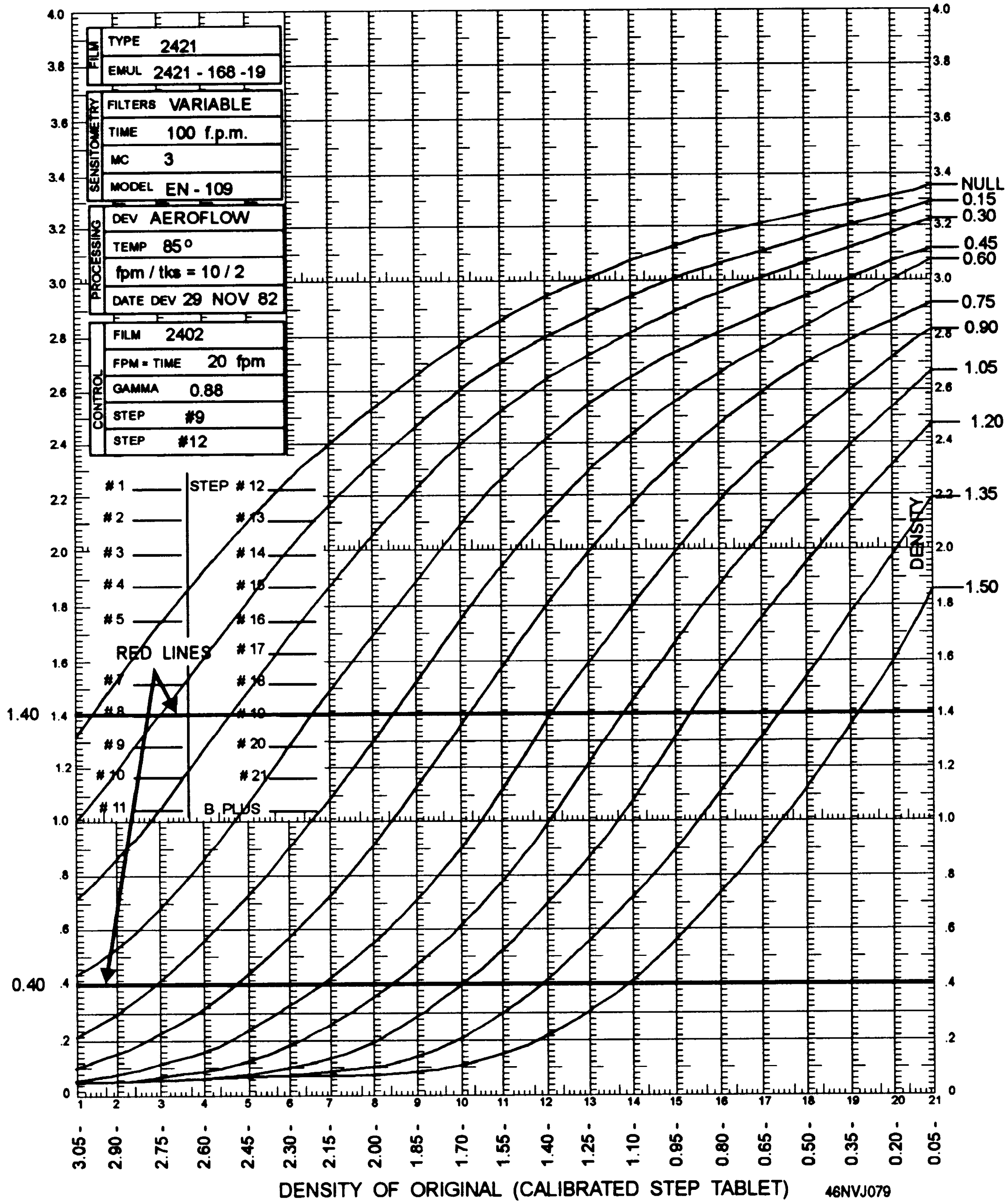


Figure 4-32.—High-contrast printer curves

Captioning for aerial intelligence photography is mandatory. It must be accomplished as outlined in the *Defense Intelligence Agency Manual*, DIAM 55-5, in the section entitled "Aerial Photography and Airborne Electronic Sensor Imagery (Forwarding, Titling, and Plotting)."